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HIGH PRECISION STEREO VIEWER

FINAL REPORT

1. PROJECT OBJECTIVES

1.1 The objectives of this project were to monitor the design and fabrication of the High Precision Stereo Viewer and to test and evaluate the instrument to determine its suitability for general Navy photo interpretation use.

1.2 Authority

STATINTL 1.3 Development, test and evaluation of the High Precision Stereo Viewer were conducted under [redacted] STATINTL [redacted] of 1 September 1964.

1.4 Background

1.5 The High Precision Stereo Viewer (Figure 1) was developed as an improved version of the High Magnification Stereo Viewer (NAVPIC report 203/63-U) developed for the Navy and delivered to the Center in late 1962.

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1.7 The prototype instrument, designated model No. 387 by the manufacturer, was highly successful in its own right as a stereo viewer. By the time it was completed, however, many improvements such as mensuration as well as greater optical and scanning versatility had become feasible through recent advancements in electro-optical technology.

1.8 The subject instrument, designated model No. 552A-101, Serial No. 103, was developed from [redacted] Proposal No. 552A of July 1963 for an improved version of the model 387 viewer.

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2. DESCRIPTION

2.1 The High Precision Stereo Viewer is a fiber optic direct viewer with measurement capability. Film transparencies in roll or chip form and of differential scales and orientations may be scanned and measured in stereo over dual 9 x 18 inch formats. The optical system provides wide versatility available at the eyepiece assembly (Figure 2) along with independently variable zoom magnification of 1.6 to 128 times. The instrument is comprised of three caster mounted units. The viewing console, or major unit with felt padded leveling jacks is 92 inches long

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by 54 inches in width (38 inches with shelf folded) and 65 inches in height to the top of the cantilevered eyepiece carrying arm. The other two units are both 18.5 by 26 inches and 33 inches in height. They are the control cabinet (Figures 1 and 3) and the power/vacuum cabinet (not shown). Input power requirements are 115 volts (±10V), single phase, 30 amp, 60 cycle current. In full operation, including the vacuum unit, the viewer uses about 17 amps with a momentary surge to 25 amps upon actuation of the vacuum unit switch.

2.2 Optical System. Considerable optical versatility is incorporated in this viewer. The optical system provides eye station reversal, image inversion, binocular monoscopic viewing, superimposition and full rotation. Three optical dark filters in each eye path may be used in combination to provide 50, 75, or 87 per cent light attenuation or dimming. This method is used along with varying voltages to match light levels under a stereo pair of different densities to obtain a minimum difference in color. The physical characteristics of the optical system are contained in Table 1. Images are relayed from the scanning heads (Figure 4) to the eyepiece assembly by two flexible optical glass fiber bundles called "fiberscopes" by the manufacturer, [redacted] The fiberscopes are 3/4 inch square coherent fiber bundles 6 feet in length. The assembly is composed of individual fibers of 10 micron diameter (.0004 inch), sub-assembled into multi-fiber bundles of 36 fibers each (6 by 6 fibers square). The total 3/4 inch square assembly is composed of the multi-fiber bundles.

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2.3 Mechanical/Electrical Description

2.4 The scanning system provides six overlapping speed ranges with two motor speeds and three gear sizes. Two independently rotatable joystick assemblies are controlled by a master joystick. Scanning direction sense is maintained by rotating each control independently, to the same azimuth as the corresponding eyepiece. In the uncouple mode, each joystick assembly is free to respond to different magnifications used to match different scales and maintain stereo separation mechanically by driving the scanning heads at different speeds and in different directions.

2.5 Film is transported manually by two hand cranks at the front of the instrument. A single roll of film is positioned across both platens. Dual film rolls are each fed to the center, down into the instrument, out and up to the take-up spools outboard of the respective film supply spool on each side.

2.6 Film loops may be formed in single rolls to bring widely separated stereo image areas within scanning range. A constant loop of any length up to 17 feet can be formed and maintained while cranking through succeeding stereo pairs. The motorized loop forming rollers are used to carry film roll ends from the center, down internally and out to the access doors when two rolls are used as described in 2.5 above.

2.7 Film holddown is accomplished by a vacuum system consisting of small grooves in the glass platens, clear lucite plastic manifolds at the front and rear film edges and stainless steel manifolds at the center. The power/vacuum system supplies positive air pressure to raise the center manifolds and provide a protective air cushion upon which the film rides when being transported.

2.8 General illumination is provided by Aristo grids positioned below the half-inch thick frosted glass platens with rheostatically variable intensity.

2.9 High intensity illumination in the optical system is provided by two incandescent DKM lamps using 250 watts, 21.5 volts, with a rated life of 25 hours. Each rheostatically variable lamp is positioned under a scanning head at the end of a following arm and is precisely alined with and tracks each of the two optical paths.

2.10 Mensuration is provided by rotary shaft encoders which are positioned at the end of the drive screws for each of the four axes.

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2.11 The encoders are [redacted] brand non-contact magnetic encoders, manufactured by [redacted] supplying 1000 counts per revolution. Reading a translation along drive screws of 2.5 millimeter pitch, the 1000 count encoders provide a least count of 2.5 microns at the film. Power of 12 volts is supplied by the readout system which in turn receives the signals that are interpreted as counts.

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2.12 The readout system currently being used is the [redacted] Model 182 supplied by the [redacted] This is a two axis unit with six digit Nixie tube display and a patchboard which may be programmed. The two axes (x and y) of the current readout device are used alternately to read the left or right side (marked INC-1 and INC-2) selected by a toggle switch on the readout control panel. (Figure 5) The 2.5 micron increments can be read visually at the [redacted] and recorded automatically on a Friden tape punch unit in LGP-21 Computer binary code. The raw x and y dimensions may then be translated by simple formulas or computer programs to obtain actual dimensions in feet. An illuminated dot reticle is used in the center of each optical path as a reference point for measuring. A GE 1630 incandescent lamp is used. The dot reticle is located on each scanning head where size is controlled by an iris diaphragm. The apparent size to the eye is variable by a subtended angle range of one to four arc minutes at all magnifications. The intensity of the light dot is voltage variable from the console.

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3. INVESTIGATION

3.1 Engineering Tests. The following engineering tests were conducted by personnel of the Evaluation Department of the Naval Reconnaissance and Technical Support Center.

3.2 The Optical System was tested for resolution, alignment and mechanical functions which include hand operated controls as well as motorized zoom and objective lens selection. Resolution was read with a standard 1951 Air Force resolution target and a 4X optical assist at the eyepiece.

3.3 The Scanning System was tested for proper direction, speed, coupling, smoothness and controlability.

3.4 The Film Drive System was tested for effectiveness of the transport, looping and holddown mechanisms as well as smoothness, timing and film safety.

3.5 Illumination The general and high intensity illumination were tested for the adequacy of their light levels using a Spectra Brightness Spot Meter reading in Foot Lamberts. The amount of heat produced by each illumination system was tested using a thermocouple with density 1.0 film and read by a Brown Potentiometer in degrees Fahrenheit.

3.6 Mensuration The X-Y measuring system was tested with precise 9 by 9 inch glass grid plates with diagonal lines and cross hair intersections at right angles. Absolute and relative accuracy as well as repeatability were tested. Way straightness was tested at intervals of the 9 inch square intersections.

4. TEST RESULTS

4.1 The following are test results obtained in the course of investigations described in paragraph three.

4.2 Optical System The resolution obtained with this instrument exceeds the goal as may be seen in table 1 compared to the contract specifications of 8 l/mm per power at 5X linear to 5 l/mm per power at 125X magnification. The optical modes and associated controls of this instrument function properly and effectively. From four loading modes, it is possible to achieve any combination of sixteen orientations of a stereo pair on two rolls of film. However, except for demonstration purposes, no more complications than necessary should be used, to simplify set-up and scanning procedures. The image super imposition feature is especially useful in centering fields, in matching scales, rotation, and light levels of any given stereo pair. The motorized zoom was timed at 7 seconds from limit to limit. Overall placement and effectiveness of the controls is good especially considering the degree of optical versatility provided.

4.3 Scanning System. Unlimited differential rotation may be set into the optics and with corresponding joystick rotation, the scanning system maintains stereo remarkably well. With the different scanning speeds available in the uncouple mode, two vertical photos of 1:3 scale difference were scanned with good stereo maintenance. The six scanning speeds range from .0006 to 45 inches per minute; more than adequate to accomplish three distinct operations of slewing, scanning and point positioning. The actual speed ranges that were tested are contained in Table 3. Speed range number three (slow motor-high gear) is not recommended for routine use due to its lack of smoothness. For several actual pointing operation problems, it was found that switching between speed ranges 4 and 6 suited the need for precisely placing the dot reticle on one desired image point and rapidly scanning to the next. This meant switching from range four to six or low to high gear. A metal tab was added to the gear selection lever to give it more prominence and to ease the basically stiff action of the toggle switch used in this control.

4.4 Film Drive System. The manual film transport was found to be adequate and the vacuum film holddown action was completed within one to two seconds. A delay valve to allow the operator time to draw the film tight before vacuum pulldown is not currently being used, because this added step was found to be unnecessary. Roll film scratching was essentially eliminated by precisely aligning all the rollers and guides as well as spacing the rear clear lucite vacuum manifolds vertically from the glass platens at more than .010 inch clearance. The loop forming mechanism was timed at 50 seconds for both forming and returning the largest loop of 17 feet. The general effectiveness of the film handling system was found to be satisfactory.

4.5 Illumination. The general and high intensity illuminations were found to meet adequately the design goals. Readings in Foot Lamberts are shown in Tables 1 and 2. Heat produced by the general illumination was 83 degrees F. Heat produced by the maximum high intensity illumination leveled off in less than 30 minutes at a high of 125.5 degrees F. from an ambient 77 degrees F. Both are within acceptable limits.

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4.6 Mensuration. Accuracy and repeatability of the X-Y measuring system is good. The 2.5 micron least count is large enough that no perceptible deviation was detected with available test equipment. The [redacted] readout with wire patchboard allows an infinite variety in arrangement of output information. Hard copy from the Librascope computer typewriter is being used with simple calculator formulas for preliminary investigation of mathematical conversion and rectification.

5. DISCUSSION.

5.1 Mensuration. Computer programs are being developed to utilize the automatic characteristics of the measurements available with this instrument to drive the EAI Dataplotter for automatic plots in a point to point sequence.

5.2 Fiber Optic Bundles. Although the quality of the total fiber optic assembly cross-section is good, it is not quite as good as the smaller (½ inch square) bundles used in the 387 prototype. The reason for this is reported to be greater difficulty in the manufacture of the larger bundles. The result is more irregular voids between multi-fibers thereby increasing the percentage of total void area. Determination of the performance of the fiber optics can be made by measuring the breakage of the multi-fibers. In the 387 model, it was estimated that when breakage of the multi-fibers (from constant flexing during scanning) reached 5%, the cables should be replaced. Periodic photographs from the time of installation in October 1962 to August 1966 show that by actual count, multi-fiber breakage has increased from 2.4 to 2.7 per cent. This is an increase of one quarter of one per cent (.25%). Even by a much more severe count, breakage over the four year period could be said to remain between 2 and 3 per cent. Since the physical dynamics required by the 552-A cables, even though they are slightly larger, are nearly identical to those of the 387 viewer, the outlook is good for nearly negligible deterioration of the fiber cables.

5.3 Human Factors. Although not tested, the noise level produced by this instrument should be considered in determining its location. The six muffin fans used produce a steady hum of a level foreign to the usual P.I. space. The image enhancer motors add to the basic noise level. The vacuum film holddown also adds to the total noise level produced by this instrument. Indications are that maximum utility of this instrument will probably be gained by installation in an isolated P.I. working space such as a nearby instrument room. A location such as this provides room for different groups to utilize the subject instrument as well as associated equipment such as computers, plotters and storage and retrieval units for reference materials.

5.4 Improvements. Since the design of this instrument, improvements that have become feasible (some of which may be seen in Figure 6) are anamorphic eyepieces, motorized film drive, flicker mechanisms for change detection, encoders of different and variable count rates, additional looping, film cleaning unit, chip storage/viewing, automatic stereo correlation, television monitoring, and sub-micron laser interferometer measuring systems. Some of these and other concepts will make their need felt and lend themselves to retrofitting to this instrument in the future. Should a finer count or more accurate measuring system be contemplated for retrofitting to this instrument, a preliminary study should be made using a reading system removed from the driving screws such as optical scales or laser interferometry with a finer count, reading to one micron or less. Precise stage location in relation to optics could then be used to detect discrepancies such as drive screw play or warpage accurately over the entire length of the ways. This type of information could be used to indicate the precise cut-off point in feasibility of mensuration accuracy and methods for retrofitting in this instrument. Other improvements which could be utilized are auxilliary keyboard and typewriter units

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available for the Telecordex to give additional symbol capability and additional axis readers. Reading four measurement axes in the subject viewer in stereo with the present two axis reader, the measuring sequence must be repeated for the left and right side alternately. Adding two axes to the present readout or purchase of a four axis unit would provide the capability of simultaneous measurement of both images in a stereo pair.

6. CONCLUSIONS

6.1 The High Precision Stereo Viewer is entirely useful in its present form for Navy photographic interpretation use.

6.2 This viewer offers good optical quality and versatility for use in detailed photo interpretation. The high resolution stereo viewing versatility and measuring capabilities of this unit could make it a key instrument in helping to make the transition from present hand methods to computerized real time photo interpretation.

7. RECOMMENDATIONS

7.1 It is recommended that the viewer be used operationally within the Command for detailed photo interpretation.

7.2 It is recommended that the Center continue to investigate possible improvements in the viewer itself as well as mensuration techniques and programs to widen the utility and application of the instrument.

TABLE 1 OPTICAL CHARACTERISTICS

OBJECTIVE LENS NUMBER		1		2		3		4	
Objective Lens Rating (X)		.5		.9		3.2		9.5	
4:1 Zoom Magnification Position		Low	High	Low	High	Low	High	Low	High
Zoom Magnification Rating (X)		.7	3	.7	3	.7	3	.7	3
Nominal System Mag. (with 4.45X eyepiece)		1.6	6.	2.9	12	10.1	43	30	128
System Resolution (Lines/Millimeter)		13	57	26	91	114	332	256	645
Lines/Millimeter Per Magnification		8.1	8.4	8.9	7.6	11.3	7.5	8.5	5.0
Field of View (mm)		60	14	35	8	9	2	3	.7
Max. High Intensity Illumination available on axis at eyepiece (in foot lamberts)	Left	250	110	600	300	900	135	2400	165
	Right	320	110	750	320	700	120	2300	180

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TABLE 2 GENERAL ILLUMINATION

Readings in Foot Lamberts normal to surface of film plane.

LEFT PLATEN			RIGHT PLATEN		
1200	1250	1200	1000	1100	1050
1250	1250	1200	1050	1200	1100
1100	1150	1050	900	950	950

TABLE 3 SCANNING SPEEDS

			Speeds in inches per minute			
			Max. Zoom		Min. Zoom	
Speed	Motor	Gear	Range	(In/Min)	Range	(In/Min)
1	slow	low	.0006	- .010	.003	- .050
2	slow	med	.0045	- .080	.020	- .350
3	slow	high	.030	- .550	.150	- 2.50
4	fast	low	.010	- .200	.050	- .90
5	fast	med	.080	- 1.50	.350	- 6.50
6	fast	high	.550	- 10.0	2.50	- 45.0

Enclosure (1)

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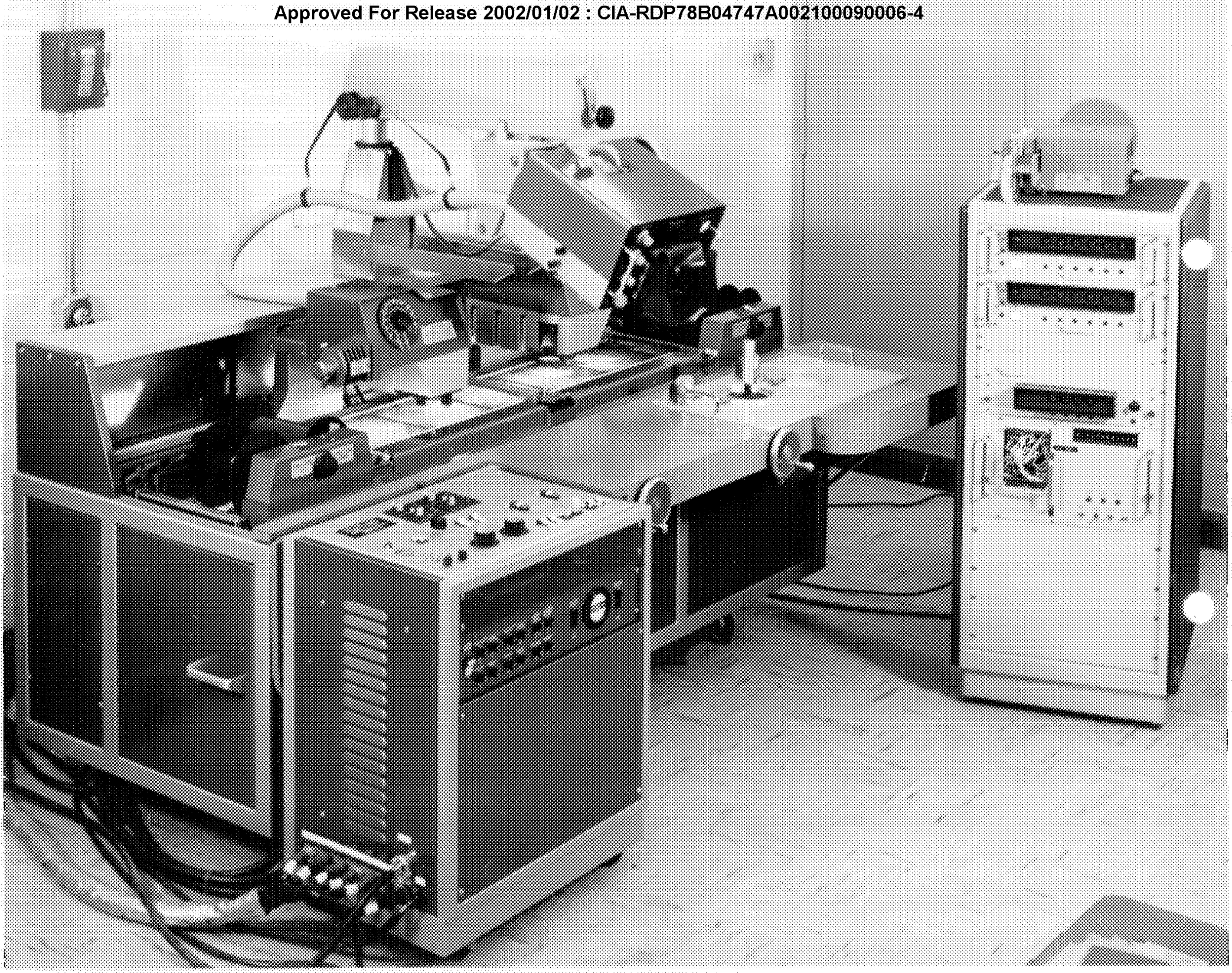

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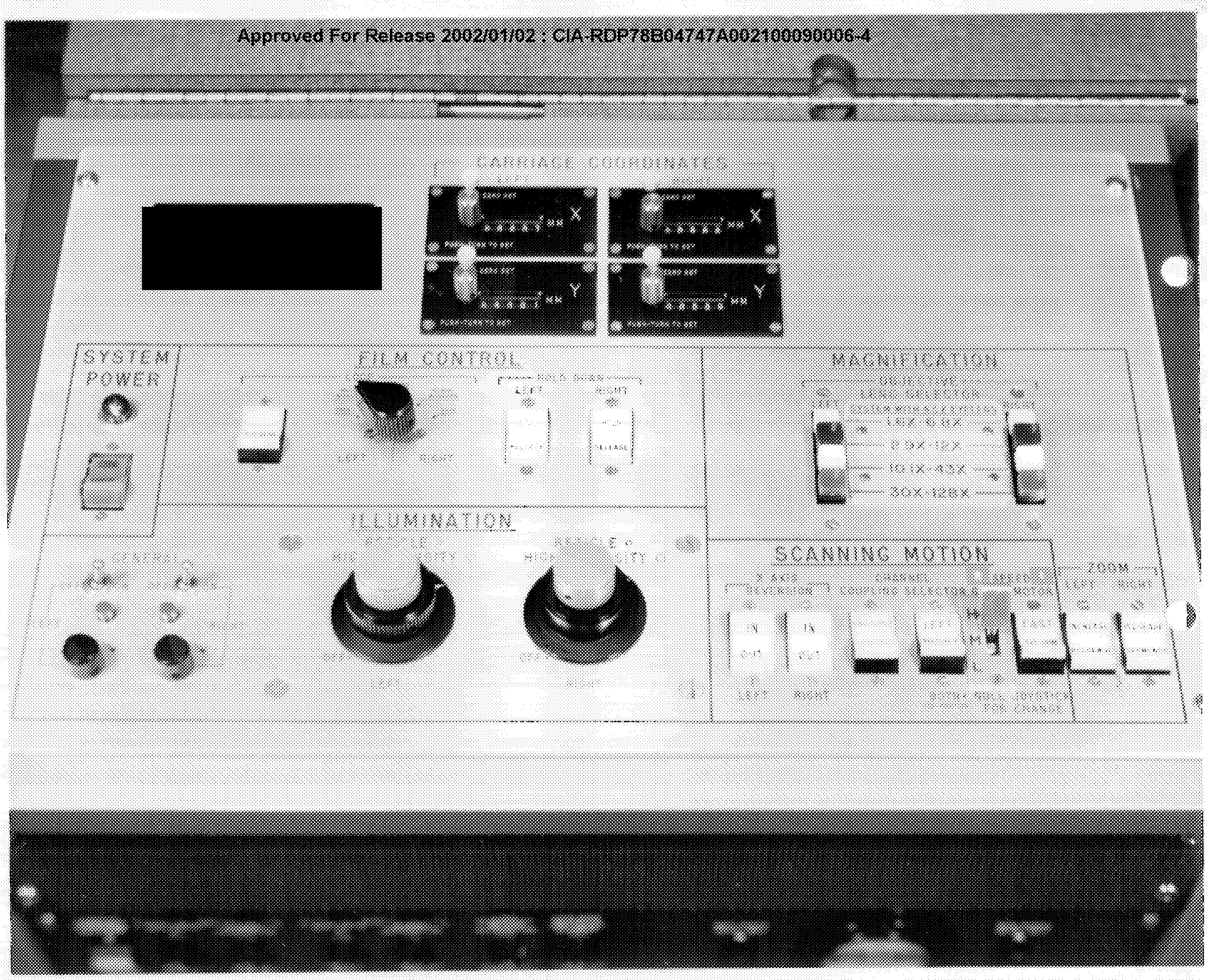

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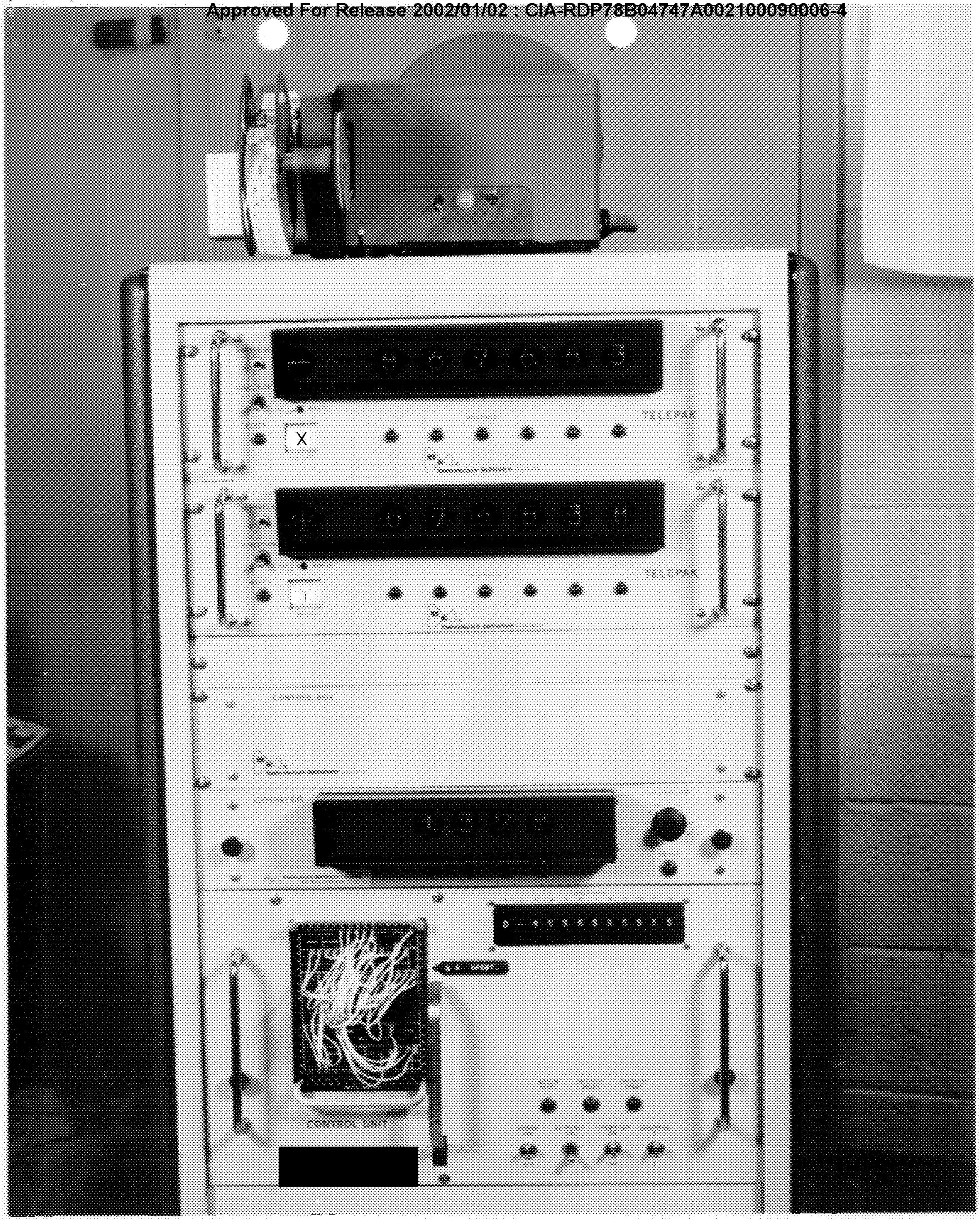

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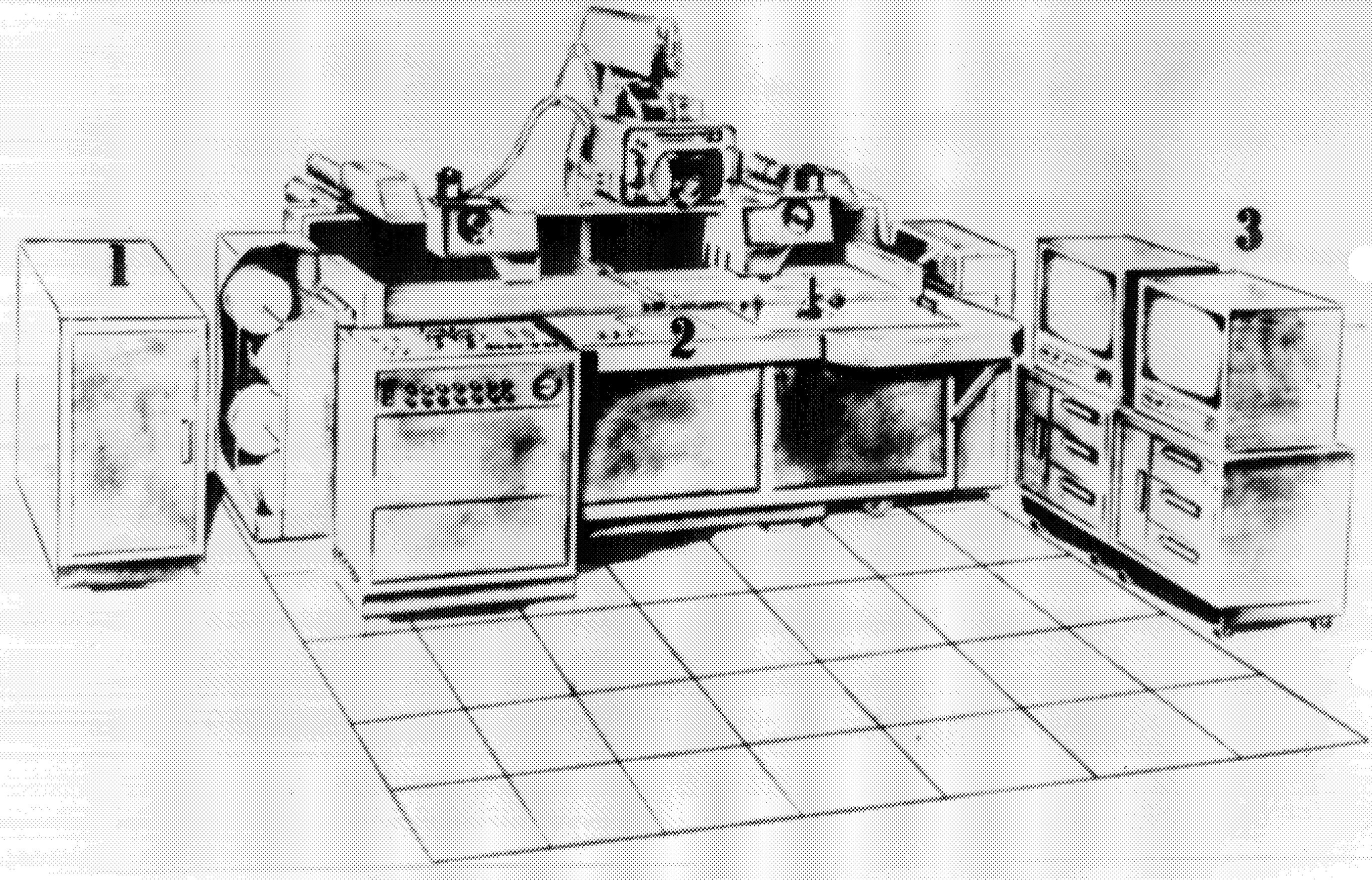

1. Film cleaning or additional film looping cabinet
2. Video monitoring or film chip viewing
3. Video monitoring

Figure 6. 571-U CONCEPT

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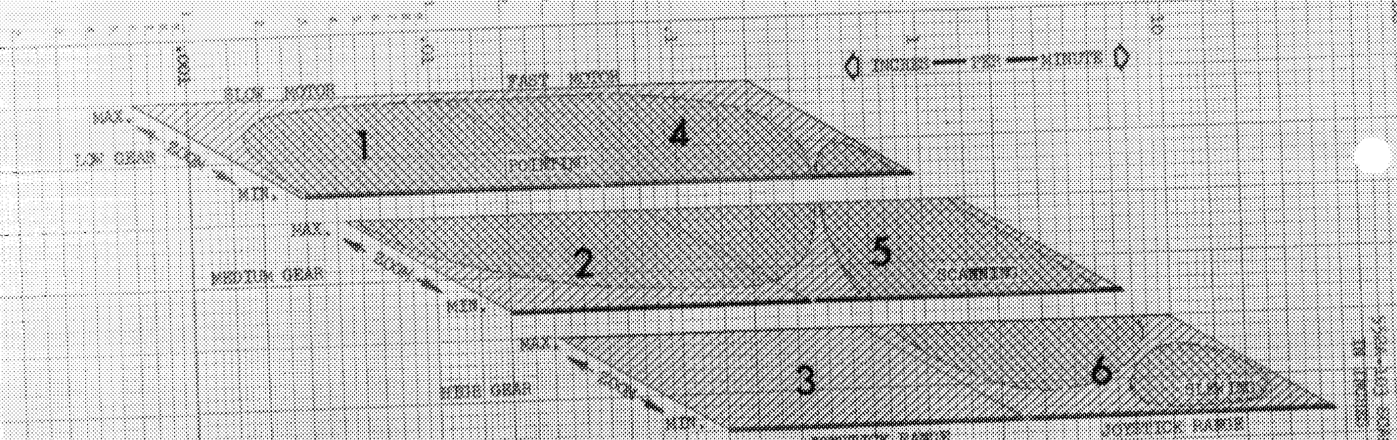

SPEED	MOTOR	GEAR	MAX. ZOOM RANGE (IN/MIN)	MIN. ZOOM RANGE (IN/MIN)
1	slow	low	.0006 - .010	.003 - .050
2	slow	med	.0045 - .080	.020 - .350
3	slow	high	.030 - .550	.150 - 2.50
4	fast	low	.010 - .200	.050 - .90
5	fast	med	.080 - 1.50	.350 - 6.50
6	fast	high	.550 - 10.0	2.50 - 45.0

UNCOUPLE MODE ONLY

COUPLE MODE (NOT INFLUENCED BY ZOOM SETTING)

SPEED ZONES OF ESTIMATED USAGE

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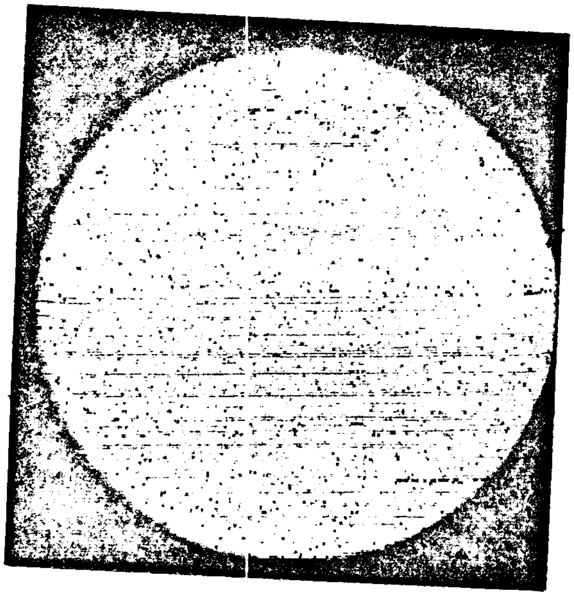
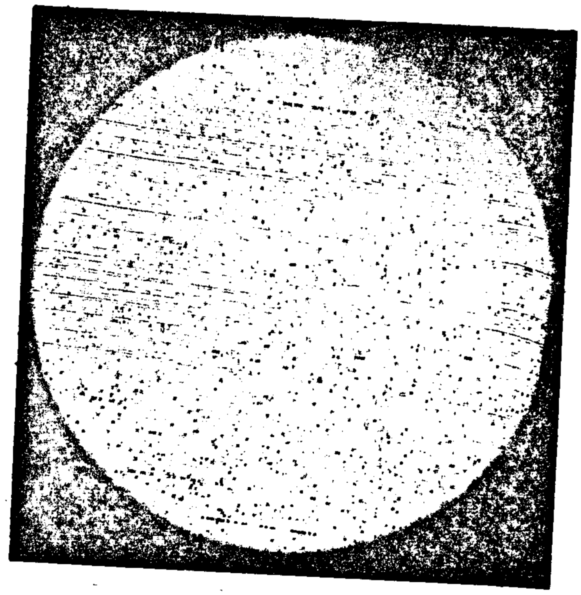
STATINTL [redacted] High Magnification Stereo Viewer
Model 387 (prototype) Fiberscopes (½" x ½" x 6')

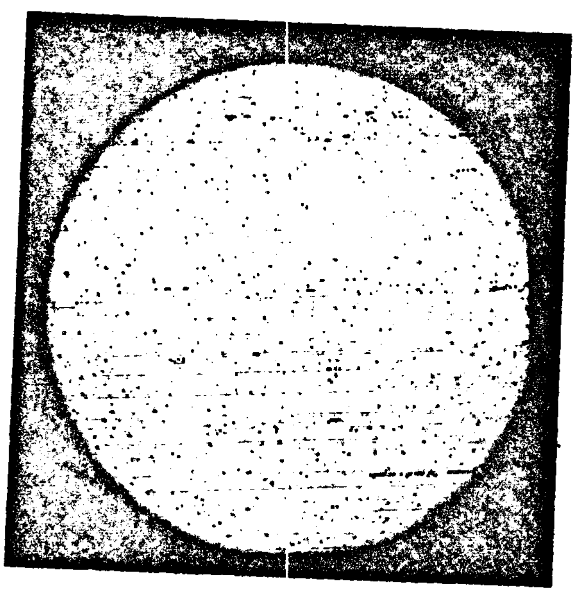


LEFT 10-62
2.63% Breakage

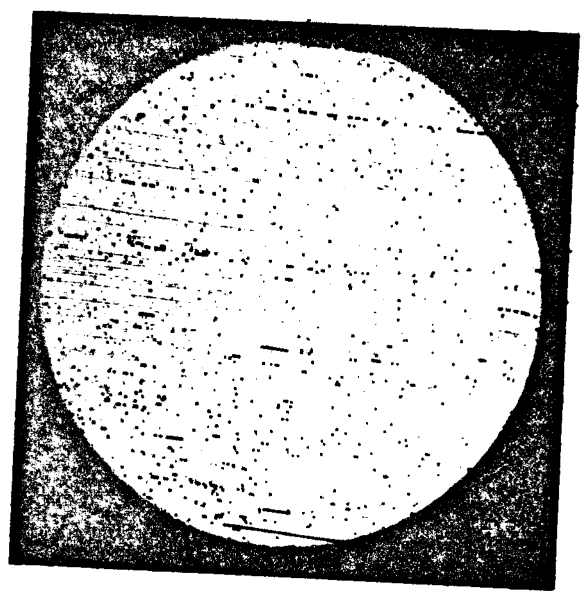


RIGHT 10-62
2.20% Breakage

At time of manufacture of cable in October 1962



LEFT 8-66
2.89% Breakage
(.25% Increase)



RIGHT 8-66
2.43% Breakage
(.23% Increase

In August 1966, three years, ten months later

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